Digital Imaging

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DIN/PACS/RIS Definitions

DIN = Digital Imaging Network

PACS = Picture Archiving & Communication System

RIS = Radiology Information System

- PACS/RIS are medical devices, not merely information systems.
- Complex automation systems for acquiring, transmitting, managing, storing and displaying digital diagnostic images and associated text information.
- PACS/RIS systems are the application of information age technology to *improve the quality and efficiency* of radiology services.
- Enable integration of new and existing medical record data including image, biosignal, textual and demographic data toward a filmless and paperless operation.

Goldszal et al., 2000

Why PACS/RIS?

- Decrease number of repeated examinations.
- Decrease/eliminate film and chemical costs.
- Decrease turnaround time of exams.
- Improve access to prior studies.
- Improve the quality of images.
- Decrease frequency of misidentified images.
- Improve equipment availability.
- Improve efficiency of after-hours interpretation.
- Improve availability of images and reports.
- Minimize/eliminate lost films.

Goldszal et al., 2000

Additional Motivation for PACS/RIS

- Acquire, distribute and archive images from all medical imaging modalities in digital form;
- Use fast networking for transferring and accessing any part of a patient's file from any location within NIH/outside;
- Reduce the time needed for an examination to become available to the attending and referring physicians;
- Support to interhospital data exchange (teleradiology/telemedicine).
- Improve medical image interpretation with the use of image processing tools (e.g., multimodality image registration, segmentation, enhancement, etc.);
- Facilitate short- and long-term image and medical data archiving.

Goldszal et al., 2000

NIH Imaging Sciences: Imaging Modalities


MRI


CT


DR


CR


Angio


CT


Fluoro


Ultrasound

Ultrasound Mini-PACS


Film Digitizer

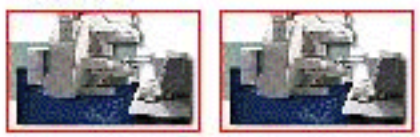

Mammo


MRI

(Suburban Hospital)


OC-12


Nuclear Medicine


PET

Nuc Med/PET
Mini-PACS

PACS/RIS
Data Center

Digital Imaging
Network

(future)


NMR Center

Goldszal et al., 2000

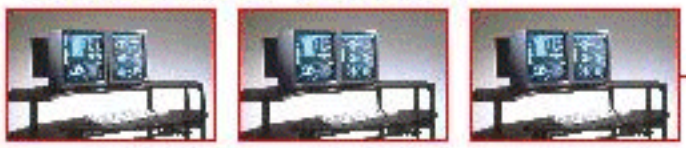
PACS Viewing Stations

CR/DR/Specials/Consulting 4-hdr 2.5K AutoRads (Cemax)

MR/CT/Neuro 4-hdr 1.5K AutoRads (Cemax)

Clinical Consulting Flat-Screen
4-hdr 1.5K AutoRads (Cemax)

Neuro/ICU/Surgery AutoRads
2-hdr 1.5K (Cemax)

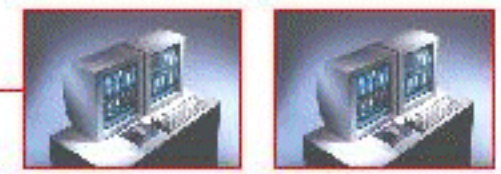


QC/Film Library/Clinic(s) Clinical AutoRads

Nuc Med/PET (MedImage)

MR/CT/Neuro AWWs (GE)

MR/CT/Neuro 2-hdr AWWs (GE)



Ultrasound (Acuson)

PACS/RIS
Data Center

Digital Imaging
Network

Web Servers

200 comm ports
for 2,000 users

Dry Printers

Color Laser

Wet Printers (Kodak 2180s)

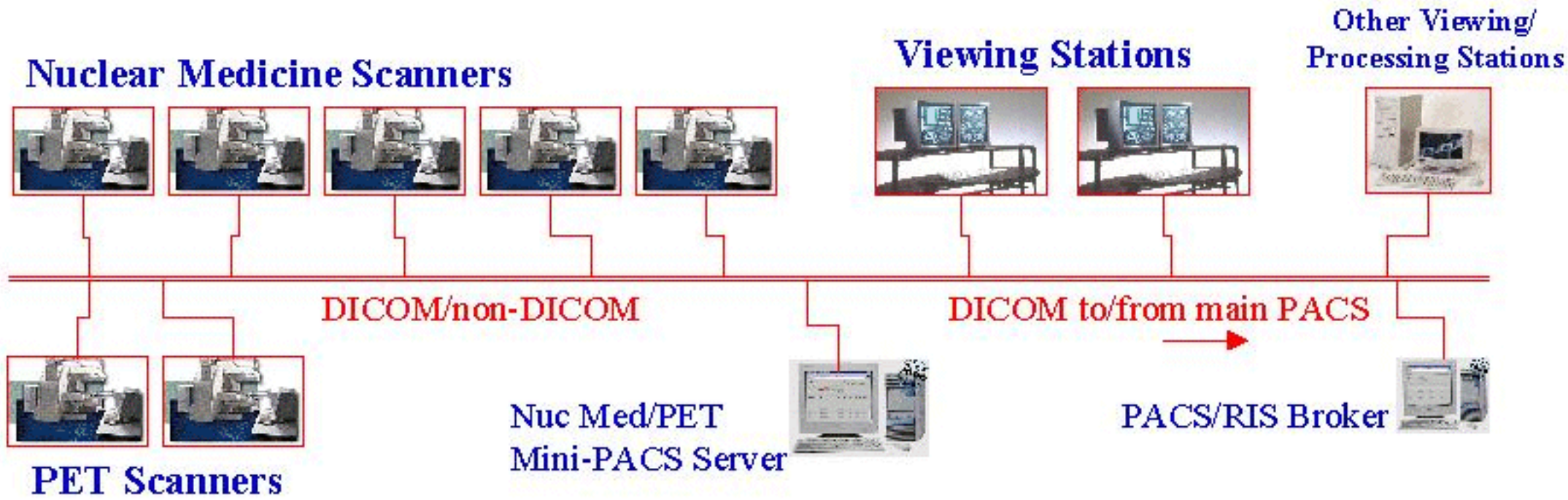
Clinical
Access
Server

50 clinical
users

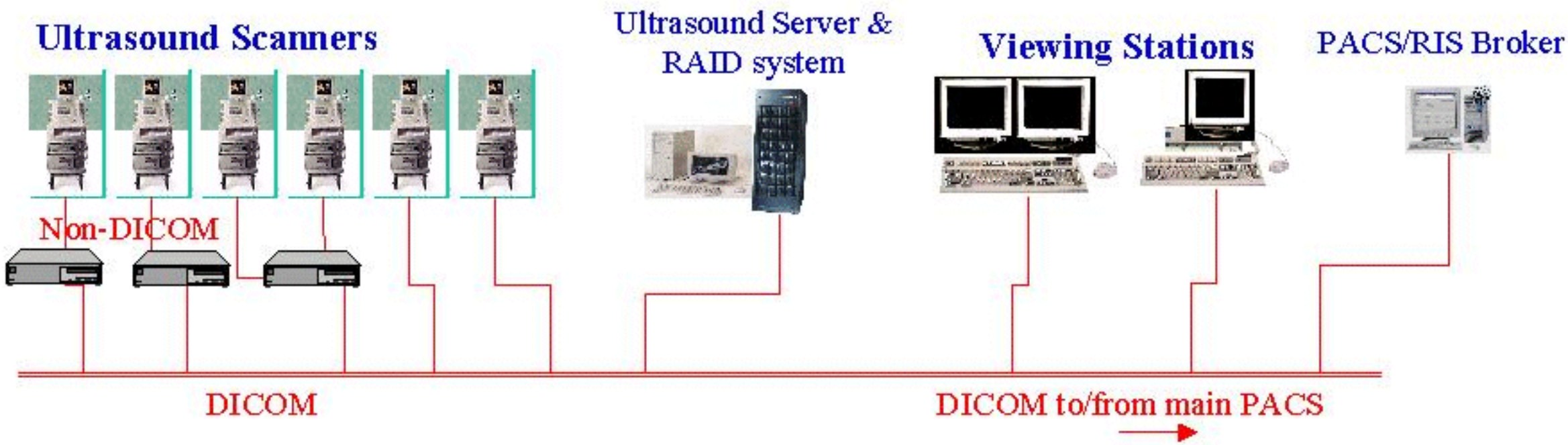
Any validated DICOM Q/R

Goldszal et al., 2000

Nuc Med/PET Mini-PACS



Ultrasound Mini-PACS



Goldszal et al., 2000

PACS/RIS Data Management Center

DICOM Servers

Study Server w/ Fibre Channel RAID

ArchiveManager Workflow Router

AutoRads Workgroup

DICOM Servers

Archive Manager 1
9740 @ 13 TB

Archive Manager 2
9740 @ 13 TB

ArchiveManager Redundancy Unit

Wet/Dry Film/Laser Printers

Clinical Access Server

DICOM/jpeg

Web Server, 200/2000

DICOM/jpeg

Any validated DICOM Q/R

Hot-spare

RS6000

PACS/RIS Broker

RIS

HL-7

HIS/MIS

Goldszal et al., 2000

Digital Imaging Network (DIN)

- Redundant (at highest level) meshed network;
- High-performance, gigabit and multi-layer intelligence (up to 150Mpps);
- 4GB backbone (full-duplex), 32GB backplane;
- Support multiple protocol and VLAN switching;
- Initially, network with 225 copper drops; each drop consists of 2 CAT5 cables using redundant wire paths;
- Fiber cabling for 25 drops;
- Cisco Works 2000 network monitoring package;
- 24x7 coverage by Kodak;
- Two Pix firewall servers (full redundancy); encryption soft; VPN soft; Secure ID; PACS/RIS security policy

Goldszal et al., 2000

PACS: Web Solution

Scanner

Server

Reading Station

Tape

RAID

Disk

Tape

Push New Imgs

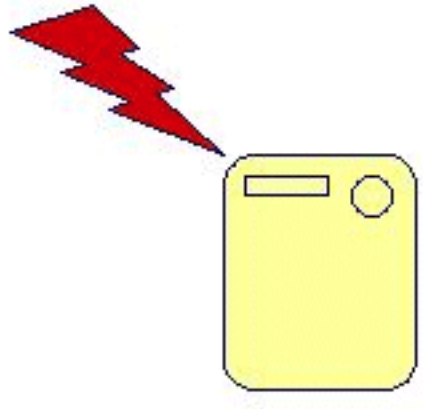
Q/R

Physician/ Scientist

Email

Q/R

Web-server



1-800-NIH BEEP

Pager

Goldszal et al., 2000

PACS: Support for Image Processing

Scanner

Server

Reading Station

DLT

RAID

Disk

DLT

Web-server

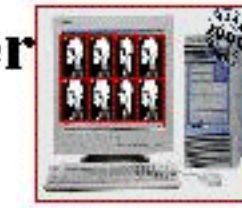


Image Segmentation	Synthesis of Parametric Images
Computational Anatomy	Data Visualization
Multimodality Image Registration	Image-guided surgery and treatment planning

Goldszal et al., 2000

PACS/RIS/HIS Workflow: Enterprise-wide Integration

4
Imaging Modality

DICOM Gateway

Images →

Images →

DICOM Storage
← Commitment

5
PACS Archive

← Study status

DICOM Modality
← Worklist

Pre-fetch images →
Route images →

Rule-based priors

HIS

1

ADT, Orders, Schedule →

3

PACS/RIS Broker

Workflow and Worklist Manager

← Radiologist worklist

Q/R

2

RIS

Status, Results, Charges

HL-7

Images ↓

Images, Reports

Study read/ verified

6

Dx W/S

Reports →

8

Enterprise-wide Access

← Q/R →

Web Server: Images & Reports

Clinical Server: Images & Reports

7

Clinical W/S

Goldszal et al., 2000

Radiology Information System

Purpose:
To connect the appropriate persons, knowledge, and resources at the appropriate time and location to achieve the optimal health outcome.

What Capabilities are Available to CC/NIH?

- Diagnostic Radiology
- Radiology Tracking
- Departmental Scheduling
- Discern Explorer and Discern Expert
- Voice Recognition
- Interfaces
- PACS integration

Goldszal et al., 2000

Diagnostic Radiology Components

Components of Diagnostic Radiology to help manage its services.

- **Departmental Patient Registration**
- **Departmental Order Entry and Inquiry**
- **Image Management**
- **Report Processing**
- **Radiologist Desktop**
- **Quality Management**
- **Mammography QA and Patient Follow-Up**
- **Workload and Management Reporting**
- **Bar Code Reading capability**
- **Departmental Charting**
- **Charge Capture/Reporting**
- **System Operations**
- **Data Archive Management**
- **System Support**
- **Database Administration**
- **Accession Linking**

Goldszal et al., 2000

Radiology Tracking

Maintains information about the location of patients within the radiology service. Radiology Tracking allows a radiology service to keep a record of the following activities:

- The time transport was called to transfer a patient
- The time transport left to transfer a patient
- The time a patient arrived
- The time an exam was started and completed
- The time a patient entered or exited a location
- The time a patient left the radiology service

Goldszal et al., 2000

Departmental Scheduling

- **Appointment requests can be scheduled manually via an online electronic "appointment book" or by reviewing and modifying a suggested appointment schedule created by the system based on procedure and resource constraint databases.**

- **Appointments can be scheduled for up to 23 months into the future.**

- **For each scheduled procedure, the system can track a reason for performing the procedure, default comment templates, a notification message, special instructions, a transport code, a referring location, and free-text appointment comments.**

- **User-defined, procedure-specific instructions for patient preparation can be displayed at the time an appointment is booked and can be printed on the patient's schedule.**

- **One-time, series, and dependent multiple-step appointment booking is supported.**

- **Printing of appointment reminders, cancellation notices, reschedule notices, and missed appointment notices in a user-defined format is supported.**

- **When a non-Cerner system is providing requests for scheduled procedures through an orders interface, Departmental Scheduling Management optionally can notify that system when those procedures or orders are scheduled, rescheduled, or canceled, via Appointment Notifications Outgoing.**

Goldszal et al., 2000

Discern Explorer/Expert

Explorer

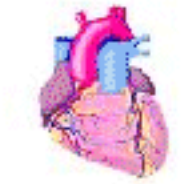
- Retrospective decision support
- 4GL, SQL-like language
- Access via command line or graphical user-friendly front end tool

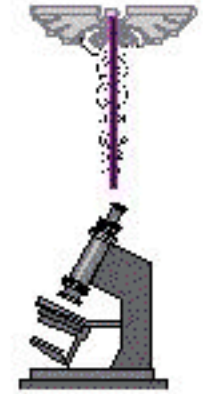
Expert

- Prospective decision support using "if, and, or, then" rules
- Clinical/operational/administrative use

Goldszal et al., 2000

Discern Expert Example





If	Carotid Angiogram is Ordered
And	Allergy to Iodine is Present
Or	Creatinine and BUN are High
Or	Taking Heparin or Coumadin
Or	Pro-Times not Ordered or Elongated

Then Notify Physician of Possible Adverse Effects Due to Decreased Renal Function or Allergy to Contrast Media

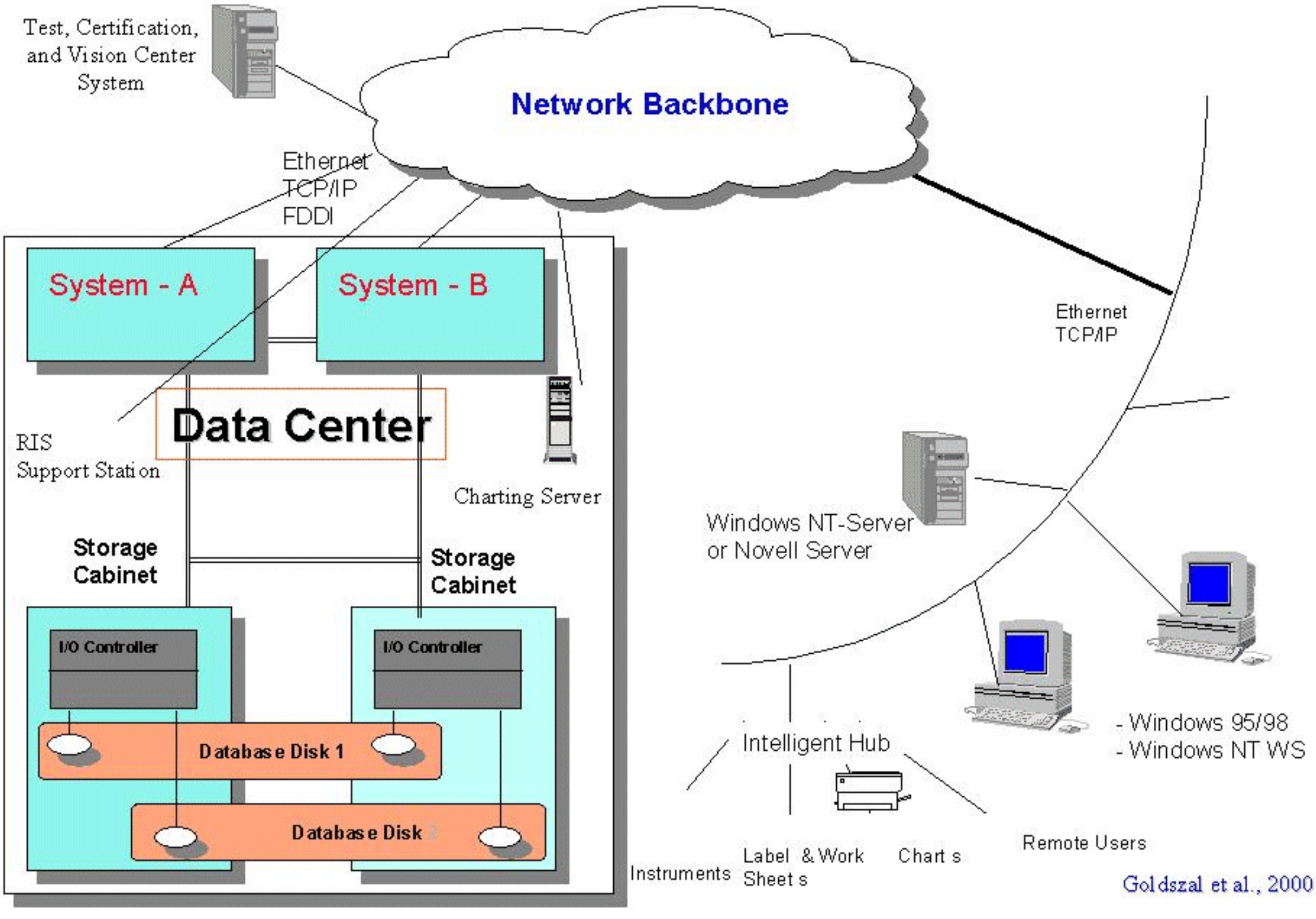
Goldszal et al., 2000

Radiology Management Reports

- Turn-around time for completion of exams
- Room and equipment utilization rates
- Exam frequencies by NIH protocol number
- Workload by employee
- Patient waiting time
- Turn-around time for diagnostic reports
- Over 500 other detailed and customizable reports are available from the RIS

Goldszal et al., 2000

Typical RIS Architecture



Goldszal et al., 2000

Benefits/Opportunities Provided by the RIS
(Improvements in Quality, Data Access and/or Cost Reductions)

- Better patient follow up via Mammography QA and Patient Follow-Up
- Better resource (people, rooms, machines) scheduling via conflict checking
- Reduced waste and repeat films
- Reduced incidence of misplaced and overdue films (Film Management)
- Reduced booking and sequencing errors through use of "Overbook" and "Conflict" warnings
- Reduced turnaround times (reduced patient waits)
- Near 100% capture of orders and orderables
- Improved workload and management reporting that provides the factual basis for corrective actions
- Patient care improvements obtained by use of duplicate checking, Discern Expert rules and clinical alerts
- Seamless integration with PACS

Goldszal et al., 2000